Influence of reservoir water level variation on slope in lab. flume test

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Influence of reservoir water level variation on slope in laboratory flume test

(preliminary study)

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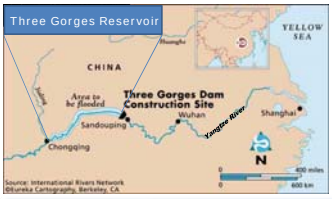
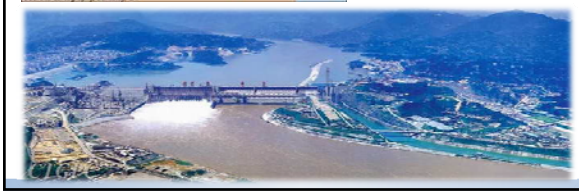
Background



The Three Gorges Dam construction on the Yangtze River in China is the largest hydro-electricity project in the world. The final dam height is 185 m and the final length 2,309.5 m. The reservoir level reached a maximum of 175 m in 2009.The rising water level caused by the Three Gorges Reservoir reached Chongqing City, about 660 km upstream from the dam site.



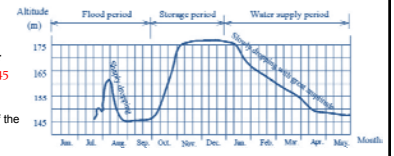
Background

The first impoundment was achieved in 2003. After the impoundment, many landslides occurred along the reservoir bank.

"More than 150 dangerous geological events were recorded within five months after the reservoir was first impounded"
——International Rivers

Landslide in the Three Gorges Reservoir, China

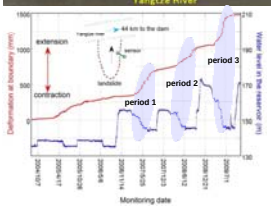
For the power generation and flood prevention, the reservoir water level changes between 145 m and 175 m every year.



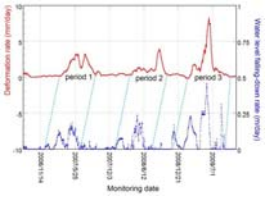
Hydrograph of the water level of the Three Gorges Reservoir, China

Background

Shuping landslide is located on the right bank of Yangtze River. It is a reactivated landslide triggered by the first impoundment of the Three Gorges Reservoir in June 2003. A monitoring system was installed in Block-1 in 2004.



Monitoring result of sensor at the east boundary of Block-1 comparing with the reservoir water level



The relationship between deformation rate and water level falling-down rate

Background

Study Purpose

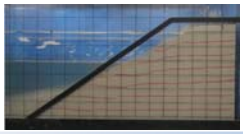
In-situ monitoring system → Laboratory test → Monitoring data / Landslide feature → In-situ displacement prediction

To study the dynamic behavior of the landslide caused by reservoir water level variation using laboratory test, and to evaluate crucial parameters to describe the effect of water level variation on landslide deformation. Theoretical model will be used for in-situ displacement prediction for the early warning in the reservoir

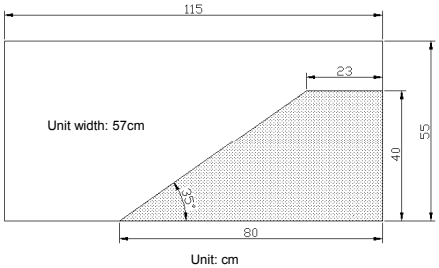
Study Method

Flume test

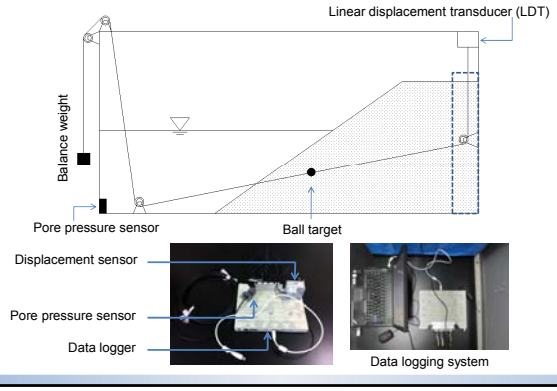
—silica sand slope model under water level variation



Description of the slope model



Arrangement of the flume test apparatus



Soil properties

Unified soil classification system	Silica Sand No.8
Specific gravity, G_s	2.66
Grain size distribution	
D_{60} (mm)	0.105
D_{30} (mm)	0.083
D_{10} (mm)	0.065
Coefficient of uniformity, C_u	1.62
Coefficient of curvature, C_c	1.01
Density, ρ (g/cm^3)	1.19
Water content, w (%)	4.80
Coefficient of permeability, k_s (m/s)	3.56e-05

Through the comparison with standard grain scale (***ISSMFE***), unified classification of silica sand No.8 is **Fine sand.**
The permeability of silica sand is **high** (1.0e-03 to 1.0e-05).

Placement of the sand inside the flume

Sample was placed layer by layer. Thickness of each layer is 5 cm.

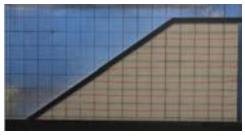
Sample was covered with a piece of wood board, and drummed 5 times using mallet.

Before putting next layer sample, layer surface was roughed using steel brush.

Placement of the sand inside the flume

Top view

Front view

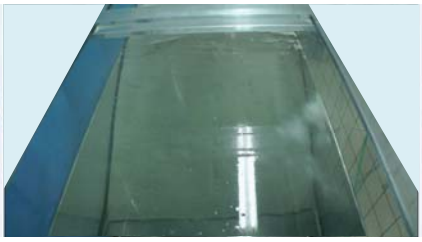


Side view

Flume test procedure

Front view

End



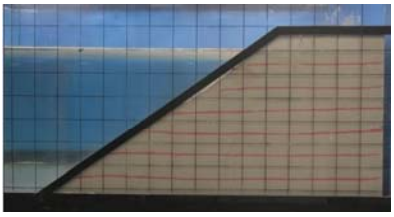
The first time of water level increase

Average rate: 2 cm/minute

Flume test procedure

Side view

End



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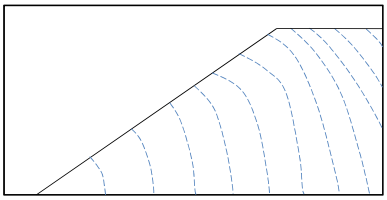
Flume test procedure



The distribution of wet front with each 20 seconds when water level increase

Flume test procedure

Front view

End

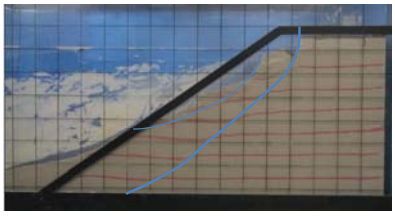
The first time of water level decrease

Average rate: 10 cm/minute

Flume test procedure

Side view

End



The first time of water level decrease

Average rate: 10 cm/minute

Flume test procedure

Front view

End

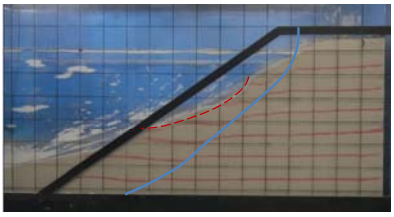
The second time of water level decrease

Average rate: 10 cm/minute

Flume test procedure

Side view

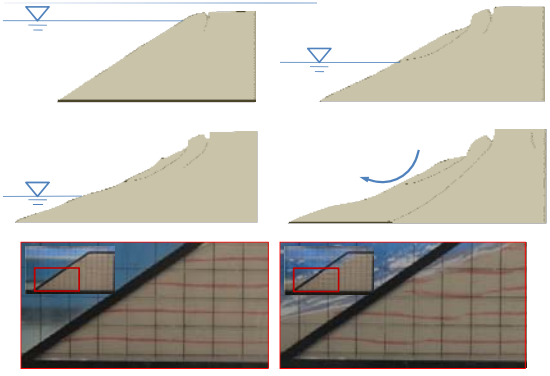
End



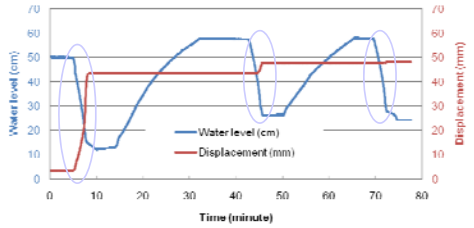
The second time of water level decrease

Average rate: 10 cm/minute

Results and discussion



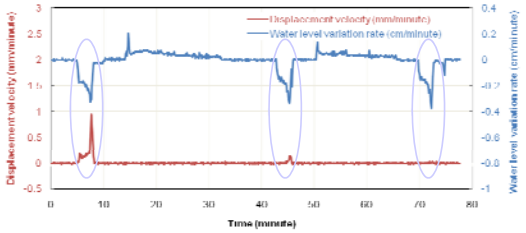
Results and discussion



Monitoring result of displacement comparing with the water level variation

The figure shows a comparison of deformation with the water level variation. The displacement shows a step-like character. The displacement has increased rapidly during water level decrease, especially the first time. And the displacement stopped for the period of water level increase and keeping at constant level.

Results and discussion



The relationship between deformation velocity and water level variation rate

The figure shows the relationship between deformation velocity and water level variation rate. During the first time of water level decrease, it is clear that the displacement has a similar variation pattern with the water level decrease rate.

Conclusions

- Test result conforms monitoring result of the Shuping landslide in the Three Gorges Reservoir, and reveals dynamic behavior of landslide caused by reservoir water level variation.
- Movement of the slope corresponds to water level change. Especially, movement occurs during periods of reservoir water level decrease. A direct relationship between the water level variation and displacement velocity was found. When the water level decreasing rate increased, the slope displacement velocity increased correspondingly.
- Based on the flume test, the prediction of landslide deformation in reservoir becomes possible.

Thanks for your attention!